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LOFAR Observations of the Initial Stage of IC Dart Leaders

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In previous work we have found that dart leaders quench needle activity; where dart leaders are charge pulses that re-trace previously established lightning leader channels, and needles are small repeating negative discharges that propagate away from positive lightning channels. We hypothesized that dart leaders could be quenching needles by carrying negative charge away from the region of needle activity. Therefore, in order to further explore the interactions between dart leaders and needles, we are investigating the beginnings of different dart leaders with the LOFAR radio telescope, which uses hundreds of antennas in northern Netherlands to image lightning in the 30-80 MHz band with meter and nanosecond level accuracy. We have found that, consistent with previous work, dart leaders start slow with weak radio emission and then accelerate over a period roughly around 50 μs in duration until they reach a maximum speed and radio intensity. However, we also observe that the power of the radio emissions from the dart leaders exhibits large, randomly-timed, variations. These variations do not appear to be a form of leader stepping. The time-differences between individual peaks in the time trace is significantly longer than the width of each peak (or pulse) that is dominated by the antenna function, (FWHM ~ 50 ns). One possible explanation could be that the power fluctuations are consistent with Poisson statistical variations of radio sources (possibly streamers), which would imply that at any point in time the radio emission is dominated by a small number of strong emitters, as opposed to millions of small streamers. A second possible explanation is that the fluctuations could be due to small-scale structural variations along the previously established plasma channel, which we have observed in previous work.